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AN EFFECT ON WEAR CHARACTERISTICS OF NANO-AL_2O_3 PARTICULATES REINFORCED AL7075 METAL MATRIX COMPOSITE

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ABSTRACT

Aluminium alloy are playing a major role in synthesizing the body parts of aerospace and automobile sector, because of its ease of production and adoptable to the modification. The hard ceramic particulates addition into the aluminium matrix will enhance the strength with respect to weight ratio and correspondingly the hardness and wear rates are getting improved both at room temperature and at elevated temperature. In this view the present work deals with the synthesis of the aluminium matrix composite reinforced with Nano-Al_2O_3 particulates at different weight percentages via liquid metallurgy method. The composite is prepared in a confined environment to maintain the homogeneous distribution of the Nano particulates over the matrix. Further the characterization of the prepared composite was carried out using SEM and XRD. Study of wear rate has been conducted by considering parameters like varying load, speed and distance. Significant results are obtained with the wear rate and worn surface study along with the homogeneous distribution of the Nano particulates over the matrix.

***KEYWORDS:** Nano Particulates, Al_2O_3, Al7075, Wear Rate & SEM and XRD*

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Original Article

INTRODUCTION

Aluminium based alloys are generally utilized in applications where weight funds are significant. However, the relatively poor wear resistance of aluminium alloys has limited their uses in certain tribological environments. By adding of hard ceramic particulate in micro or nano sizes may increase the wear resistance of room temperature and higher temperature condition [1-4]. To use composite more effectively, it is essential to understand the fundamental mechanism of wear. The wear of MMCs depends on the nature, for example, molecule reinforcement and matrix containing them. The reinforce materials like SiC, Al_2O_3, WC, Gr, B_4C, TiC and ZrO_2 are the most widely recognized artistic particles for the above reason [5-8]. Regularly, particulate reinforced composites cost not as much as fiber support composites because of engineered system, which incorporates powder metallurgy, mechanical alloying, stir casting, compocasting, rheocasting, low weight invasion, etc.[9]. The stir casting technique is the simplest and most commercial method for producing aluminium matrix composites among the above mentioned processes. Stir casting involves mechanically mixing the reinforcing particle into a bath of molten metal and transferring the mixture to the mold directly before completing its solidification. In this process, the significant thing is to make good wetting between the particulate fortification and the liquid metal [10-12]. The use of the reinforcing particulates like SiC, B_4C and Al_2O_3 are being common in

micron sizes. In the present work the much difficult use of Nano-Al_2O_3 particulates are used as reinforcement to synthesis the aluminium matrix composite by adapting stir casting methodology. The maintenance in the homogeneity of the mixture is a hard phase. The density of the Nano-Al_2O_3 particulates supports the use of same for the preparation of the lightweight composite. The composite preparation was done in a confined environment with the addition of argon gas passing at 1.5 bar pressure, which reduces the oxidation during the synthesis of the composite.

EXPERIMENTAL DETAILS

Material Selection

Al7075 is used as a matrix material, since 7XXX series of aluminium are the strongest of all the aluminium series. It can give completion in strength wise compared to steels. Also the mechanical properties of the alloy can be easily tailored through heat treatment process and can exhibit excellent strength at elevated temperature. The chemical composition of the alloy is shown in Table 1. Nano-Al_2O_3 particles purchased from Nano shell Punjab with an average size of 80 nm size with a purity of 99.99%.

Table 1: Chemical Composition of Al7075 Alloy

Chemical Composition	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al
Wt. %	0.4	0.5	1.6	0.6	2.5	0.15	1.5	0.2	Balance

Composite Preparation

A batch of matrix Al7075 placed inside a steel crucible and kept inside a resistance furnace and allowed to reach to a liquidus temperature. An argon gas setup was build to circulate inside the cubicle to avoid the oxide formation during the process. The impeller blades were designed to produce a vortex for the mixing of particles. The liquid melt is continuously stirred at a speed of 400 rpm for duration of 10 minutes and ensure the clear vortex generated and all the oxide content is popped out by the action of degasification. When the melt reaches to the liquidus temperature the preheated Nano-Al_2O_3 particles are injected by maintaining a proper flow rate. The supply of argon gas continued and constant stirring is maintained which promotes the Nano particulates to distribute evenly all over the matrix. The composite mixture was then taken to a superheated temperature of 750°C; it is poured to the preheated metallic die and allowed it to get solidified.

Wear Testing of Composite

A pin-on-disc test apparatus was used to investigate the dry sliding wear characteristics of composite specimens. The specimens were prepared and dry slide wear test was carried out as per ASTM G99 standard in DUCOM pin on disc wear test apparatus. The specimens were thoroughly cleaned before conducting examination. One end of the specimen was marked for the process in which before and after the test, specimens were weighed with a digital weighing machine with an accuracy of 0.0001g. The corresponding frictional force and wear micrometer readings are noted.

The wear test parameters considered;

- Weight percentage of Nano- Al_2O_3 (0.75, 1, 1.25, 1.5, 1.75 and 2 Wt.%).
- Applied load (10, 20 and 30 N).
- Sliding velocity (1.41 m/s, 2.82 m/s and 4.24 m/s).

- Sliding distance (500, 750 and 1000 m).

RESULTS AND DISCUSSIONS

Microstructural Characterization

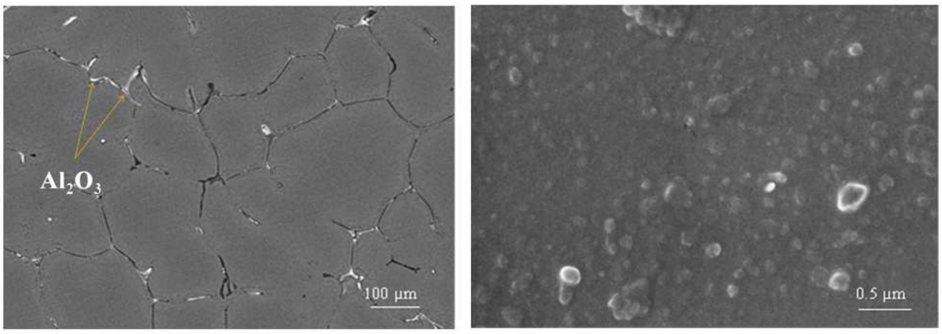

Figure 1: SEM Images of 1.5 Wt. % Al_2O_3 Nano Particulates Reinforced Al7075 Matrix Composite

Prepared composite samples are subjected to microstructural characterization and Scanning Electron Microscopy is employed to observe the distribution of the reinforcement of Nano particulates over the matrix. The test samples are sectioned from the middle portion of the composite and clear polishing was performed as per the metallographic procedure. The supply of argon gas has gives a major advantages for the composite as no oxide formation is happened and the Nano particulates are clearly settled in the boundary region of the matrix as shown in Figure.1. The effective stirring action using an impeller blade made the reinforcement to distribute all over the matrix in a homogeneous way.

X-Ray Diffraction Analysis

XRD is a technique used to identify the different phases, determination of crystalline and particle size. Figure 2 represents the X-Ray diffraction peaks for the composite prepared for different weight percentage of the reinforcement. Major intense peaks for the Al and Al_2O_3 are observed in all the XRD patterns. Followed by the addition of reinforcement also leads to the formation of many compounds like α-Al_2O_3, δ-Al_2O_3 and ZnO in minor phases. In all the peaks for different weight percent of the reinforcement addition the peaks are observed with a minute variable intensity levels at the same 2θ degree.

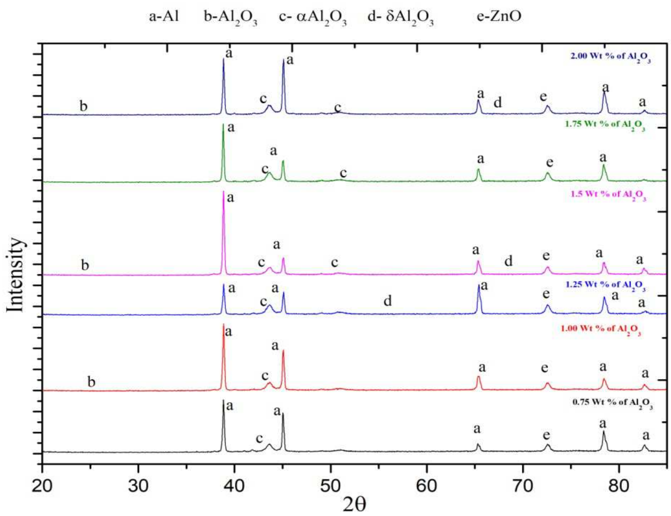

Figure 2: X-Ray Diffraction Peaks for the Composite Prepared for Different Weight Percentages

Effect of Varying Load on Wear Rate

Variation in wear rate of the composite prepared for different weight percentages of the Nano particulates addition under different loading conditions of 10, 20 and 30N are shown in Figure 3. In this condition, the two other parameters like sliding distance and sliding velocity are kept constant at 750m and 2.82 m/s respectively. For all the wear rate analysis the disc diameter was unchanged to 90cm. From Figure 3 it is clearly observed that as the percentage of the reinforcement increases the wear rate decreases correspondingly. Even at higher loads the wear rate it exhibits a complete decrement without any variation. As the load increase the pressure of the pin on the disc is also increases which results in higher wear rate. The presence of hard ceramic particulates that accumulate at the boundary region of the matrix that makes composite to resist the pressure applied.

Figure 4 represents the worn out surfaces of the composite samples subjected to SEM observation which shows no formation of oxide layer in the direction of wear. The application of the pressure on the specimen which generates a clear adhesive wear on the sample surface.

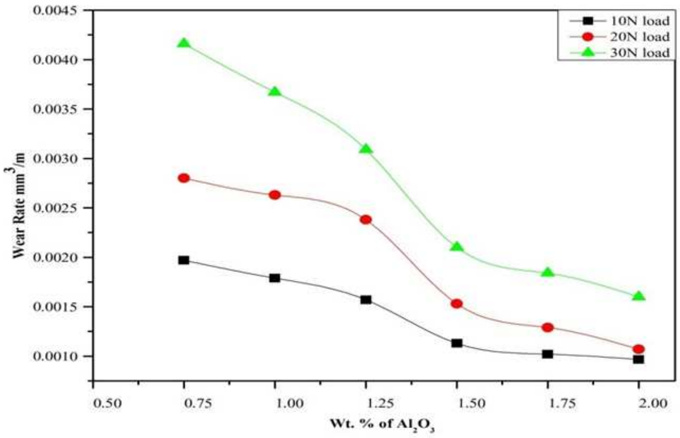

Figure 3: Variation of Wear Rate for Different Weight Percentage of the Composite at different Loading Conditions

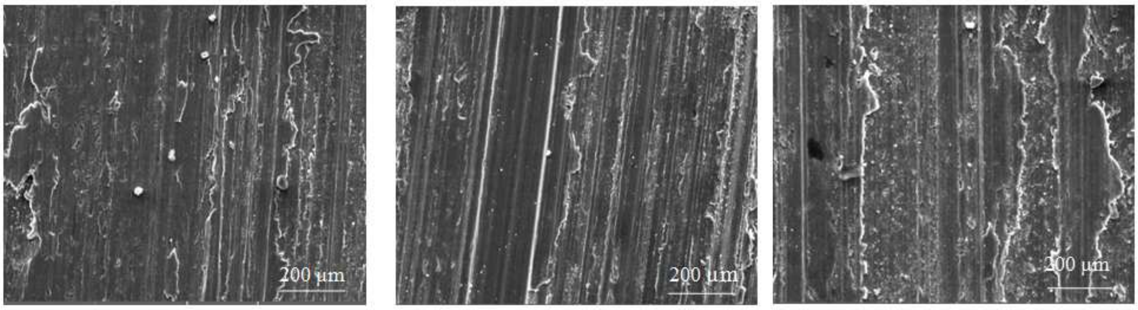

Figure 4: Worn Out Surface at 10N, 20N and 30N of the Load Application

Effect of Varying Sliding Velocity on Wear Rate

Variation in wear rate of the composite prepared for different weight percentages of the Nano particulates addition under different sliding velocity conditions of 1.41 m/s, 2.82 m/s and 4.24 m/s are shown in Figure 5. The worn out surface regions are represented in Figure.6. In this condition, the two other parameters like sliding distance and load are kept constant at 750 m and 20N respectively. For the incremental increases in the speed the wear rate of all weight percentage

composite are increased, further at individual speed as the weight percentage of the reinforcement increases the wear rate was slightly decreased up to 1.25 Wt.%. as it crosses this range the sudden drop of the gradual decrement in the wear rate can be observed. This is mainly because as the velocity increases along with the weight percentage of reinforcement the formation of the wear debris which acts as a lubricating media between the pin and the disc made the wear rate as smoother. Hence the combination of the alumina Nano particulates in the matrix has more wear resistance over different weight percentage addition of reinforcement.

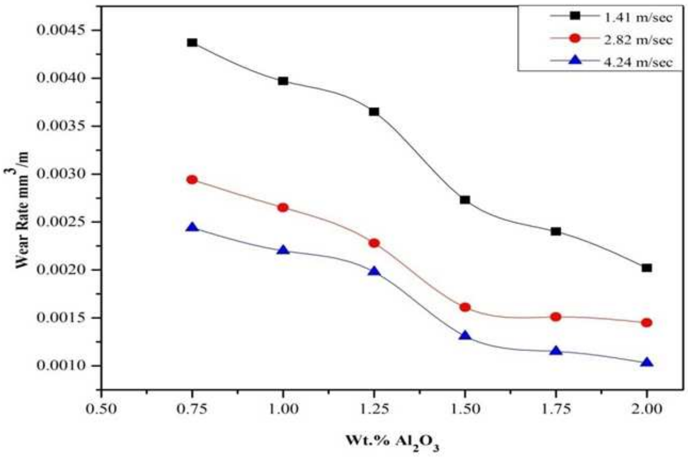

Figure 5: Variation of Wear Rate for Different Weight Percentage of the Composite at Different Sliding Velocity

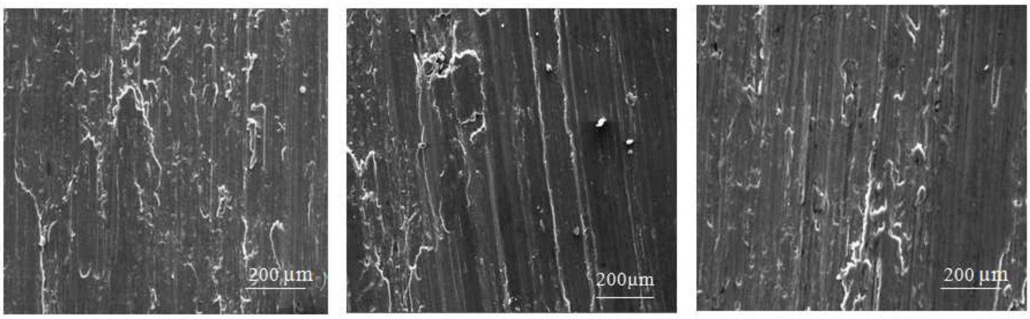

Figure 6: Worn Out Surface of the Composite Samples at Different Sliding Velocity of 1.41 m/s, 2.82 m/s and 4.24 m/s Respectively

Effect of Varying Distance on Wear Rate

Variation in wear rate of the composite prepared for different weight percentages of the Nano particulates addition under different sliding distance of 500, 750 and 1000 m are shown in Figure 7. The worn out regions are represented in Figure 8. In this condition, the two other parameters like sliding velocity and load are kept constant at 2.82 m/s and 20N respectively. The addition of Nano Al_2O_3 particulates in the matrix results in decrement of wear rate in all the conditions. The wear rate at the 750 m and at 2 Wt.% of the reinforcement wear rate is increased a bit. The continuous work of the specimens that leads to the scratchy surface of the disc part which is accumulated with the wear debris may be the reason for the increment. Further the wear rate decreases for all the variation in sliding distance for different weight percentage of the reinforcement.

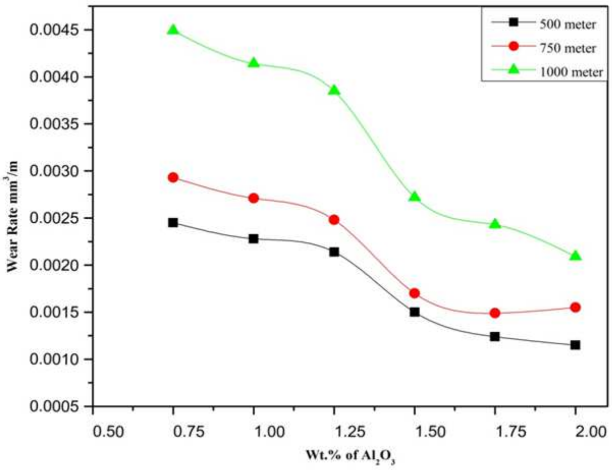

Figure 7: Variation of Wear Rate for Different Weight Percentage of the Composite by Varying Sliding Distance

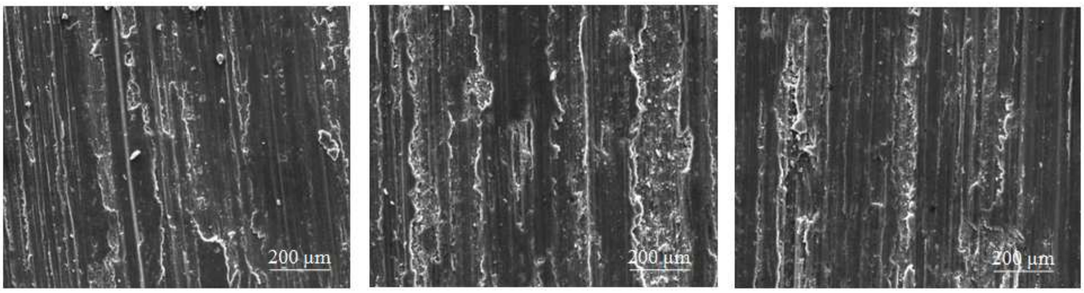

Figure 8: Worn Out Surface of the Composite Samples at Variable Sliding Distances

CONCLUSIONS

- Synthesis of Nano-Al_2O_3 particulates at different weight percentage over Al7075 matrix composites are successfully completed via stir casting method.
- Implement of argon gas supply during the complete process of casting enhance the wettability criteria of the reinforcement by reducing the oxidation.
- Microstructural characterization represents the fair uniform distribution of the reinforcement over the matrix is observed.
- Worn out surface analysis have successfully conducted to check the adhesive wear characteristics.
- Wear rate decreases in all the cases of variable load, speed and sliding distance for different weight percentage of the reinforcement addition.

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